Weed Technology. 2002. Volume 16:620–626

Volunteer Potato (*Solanum tuberosum*) Control with Herbicides and Cultivation in Onion (*Allium cepa*)[1]

RICK A. BOYDSTON[2] and MARCUS D. SEYMOUR

Abstract: Volunteer potatoes are difficult to control in onions and can greatly reduce onion growth and yield. Herbicides and cultivation were evaluated for control of simulated volunteer potatoes in onions in 1996 and 2000. Three interrow cultivations did not control potatoes in the onion row and the remaining plants reduced onion yield 50 and 73% compared with the hand-weeded checks. Three applications of oxyfluorfen (0.2 + 0.17 + 0.17 kg ai/ha) or bromoxynil plus oxyfluorfen (0.2 + 0.17 kg ai/ha) at the two-, three-, and four- to five-leaf stages of onions followed by a cultivation after each application reduced potato tuber weight 69 to 96% and tuber number 32 to 86% compared with cultivation alone and prevented onion yield loss associated with potatoes. Ethofumesate applied preemergence at 0.6 kg/ha followed by postemergence ethofumesate plus bromoxynil and cultivation reduced potato tuber weight 90% and tuber number 68% compared with cultivation alone, and onions yielded equal to hand-weeded checks. Two applications of fluroxypyr (0.3 kg ai/ha) plus bromoxynil (0.2 kg ai/ha) at the two- and three-leaf stages of onions followed by a cultivation after each application reduced potato tuber weight by greater than 90%, but onion yields were reduced 38 to 66%.
Nomenclature: Bromoxynil; ethofumesate; fluroxypyr; oxyfluorfen; onion, *Allium cepa* L. 'Fiesta' and 'Asgrow EX15120'; potato, *Solanum tuberosum* L. 'Russet Burbank'.
Additional index words: Groundkeepers (volunteer potato), tillage.
Abbreviations: POST, postemergence; PRE, preemergence.

INTRODUCTION

Numerous potato tubers are left in the field after a commercial potato harvest (R. A. Boydston, unpublished data; Lumkes 1974; Lutman 1977; Perombelon 1975). These tubers can survive and sprout in rotation crops if winter soil temperatures remain above the temperatures required to freeze tubers. Volunteer potatoes are difficult to control because of the large vegetative seed piece and the relatively deep burial depth compared with annual weeds. Volunteer potatoes also harbor harmful diseases, nematodes, and insects that harm potato crops, diminishing the positive effects of crop rotation (Thomas 1983; Wright and Bishop 1981).

Onions are often rotated with potatoes, and volunteer potatoes can severely reduce onion growth and yield. Onions are slow to germinate and emerge, and have upright narrow leaves that provide little shading and competition with weeds. As a result, control of volunteer potato in onions requires numerous cultivations, herbicide applications, and hand weeding during the season to prevent onion yield loss and potatoes from forming new tubers.

Oxyfluorfen and bromoxynil are labeled for postemergence (POST) broadleaf weed control in onions and are known to injure potatoes (R. A. Boydston, personal observation; Eberlein et al. 1993). Clopyralid injured potatoes when applied to a potato crop (Boydston 2001) and reduced the number of volunteer potato daughter tubers produced in sugar beet (*Beta vulgaris* L.) (May and Hilton 1993), but selectivity in onions may be marginal (Bond 1993; Runham et al. 1993b). Fluroxypyr suppressed volunteer potatoes in onions (Bond 1993; Runham et al. 1993b), wheat (*Triticum aestivum* L.) (Bevis and Jewell 1986; Cleal 1994; Oglivy et al. 1989), and field corn (*Zea mays* L.) (Boydston 2001) and warrants further investigation for volunteer potato control and selectivity in onions. Ethofumesate applied preemergence (PRE) and POST suppressed volunteer potatoes in carrots (*Daucus carota* L.) (R. A. Boydston, unpublished data), onions (C. Stanger, personal communication[3]), and sugar beets (Cleal et al. 1993; May and Hilton 1993) but is not currently labeled in onions.

[1] Received for publication December 10, 2001, and in revised form March 18, 2002.
[2] Plant Physiologist and Biological Technician, Irrigated Agriculture Research and Extension Center, Agricultural Research Service, United States Department of Agriculture, Prosser, WA 99350-9687. Corresponding author's E-mail: boydston@pars.ars.usda.gov.

[3] Charles Stanger, retired Weed Scientist, Oregon State University, Ontario, OR.

Two or more cultivations are required to reduce volunteer potato tuber production by more than 50% (Williams and Boydston, in press), but cultivation does not control potatoes in the crop row. Cultivation after POST herbicide treatments improves control of volunteer potatoes when compared with herbicide treatment alone and reduces the number of daughter tubers formed (Boydston 2001).

The objective of this study was to evaluate volunteer potato control by and onion tolerance to several herbicides combined with cultivation in sprinkler-irrigated onions.

MATERIALS AND METHODS

Studies were conducted on a Warden (mesic Xerollic Camborthids) sandy loam soil containing 1% organic matter, pH 7.0, near Prosser, WA. Whole-seed potato tubers, variety Russet Burbank, averaging 85 g/tuber were planted on March 29, 1996 and March 30, 2000 to simulate volunteer potatoes. Potatoes were planted with a two-row planter that placed tubers 12 cm deep in 86-cm rows at a density of 71,000 tubers/ha. Onions, var. Fiesta in 1996 and var. Asgrow EX15120 in 2000, were planted perpendicular to the potato rows in rows spaced 56 cm apart on April 5, 1996 and April 12, 2000. Plots were 2.2 by 9 m. Onions were sprinkler irrigated and fertilized according to soil tests and university recommendations.

Seventeen herbicide treatments were tested in 1996 and 13 in 2000. Treatments included a control that was cultivated at the two-, three-, and four- to five-leaf stages of onions and kept free of weeds other than potatoes by DCPA applied PRE and hand weeding, and a hand-weeded check that was kept free of all weeds including potatoes. DCPA is a common herbicide used in onions and has no activity on volunteer potatoes. In 2000 an additional control was included using DCPA and no cultivation. PRE herbicides were applied on April 8, 1996 and April 14, 2000 with a bicycle CO_2 sprayer delivering 190 L/ha at a pressure of 190 kPa through six flat fan nozzles spaced 51 cm on the boom. DCPA was applied to control annual weeds in all plots except those treated with ethofumesate. Ethofumesate applied PRE controlled the annual weeds present in these trials, so DCPA was omitted from those treatments. PRE treatments of ethofumesate or DCPA (Table 1) were incorporated with 1.3 cm of sprinkler irrigation water within 12 h after application.

POST herbicides were applied with a bicycle CO_2 sprayer delivering 470 L/ha at a pressure of 275 kPa through six flat fan nozzles spaced 51 cm on the boom. POST herbicide treatments (Table 1) were applied on May 20, June 5, and June 19, 1996 and on May 25, June 9, and June 26, 2000 when onions had two, three, and four to five leaves, respectively. Treatments containing clopyralid and fluroxypyr were combined with bromoxynil to broaden the spectrum of broadleaf weeds controlled. Onions were cultivated 7 to 10 d after each POST herbicide application in both years, with sweeps and knives to within 5 cm of the onion row. Clethodim was applied at 0.14 kg ai/ha to all plots in late July to control late-season annual grass weed escapes.

Potato control was visually rated on June 25, 1996 and June 26, 2000 using a scale of 0 to 100%, where 0 = no control and 100 = plant death. Natural infestations of Colorado potato beetle [*Leptinotarsa decemlineata* (Say)] were allowed to develop in all plots and defoliated the remaining potato foliage in late season. Onions were harvested and weighed on August 29, 1996 and September 12, 2000 from 6 m of the middle two rows of each four-row plot and sized by diameter. Potato tuber yield was determined in September by digging, weighing, and counting tubers from a 1- by 6-m area at the center of each plot. Bevis and Jewel (1986) reported increased tuber rotting of the fluroxypyr-treated tubers that were stored. Therefore, in 2000, potato tubers were collected from fluroxypyr-treated plots and cultivated checks, stored at 5 C for 3.5 mo, and then sprouted at 20 C in the dark for 3 wk, and the number of shoots per tuber was recorded.

The experiment was a randomized complete block design with four replications of treatments. Data were tested for homogeneity of variance and subjected to ANOVA. When variances were not homogeneous according to Bartlett's test, data were either arcsine, square root, or log transformed until Bartlett's test of homogeneity was met. Treatment means were separated by the LSD test at $\alpha = 0.05$. Because of differences in treatments between years, each year is presented separately.

RESULTS

Potato Control. All herbicide treatments followed by cultivation reduced the number and weight of potato tubers produced compared with cultivated checks, with the exception of 0.2 kg/ha of oxyfluorfen applied at the two- and three-leaf onion stages in 2000 on tuber number (Table 1). Potato control in late June ranged from 31 to 100% and was generally greatest with treatments containing oxyfluorfen applied three times or fluroxypyr applied twice (Table 1). Three cultivations did not adequately control potatoes or prevent onion yield loss in

Table 1. Potato control in onions with herbicides and cultivation in 1996 and 2000.[a]

Preemergence	Herbicide	Onion stage when herbicide was applied: Two leaf	Three leaf	Four to five leaf	1996[b] Potato control[c]	1996 Potato turber no.	1996 Potato turber wt.	2000 Potato control[c]	2000 Potato tuber no.	2000 Potato tuber wt.[d]
(kg ai/ha)		(kg ai/ha)			(%)	(no./m²)	(g/m²)	(%)	(no./m²)	(g/m²)
DCPA 9	Bromoxynil	0.3	0.3	—	33 f	15 bc	1,580 b	45 cd	8 de	140 de
DCPA 9	Bromoxynil	0.3	0.3	0.3	53 def	12 bcde	870 cd	45 cd	7 de	101 def
DCPA 9	Oxyfluorfen	0.2	0.2	—	75 bcd	14 bcd	790 cd	96 ab	16 bc	348 c
DCPA 9	Oxyfluorfen	0.2	0.17	0.17	94 a	9 def	189 e	94 b	15 c	325 c
DCPA 9	Bromoxynil + oxyfluorfen	0.2 + 0.17	0.2 + 0.17	—	65 de	18 b	1,300 bc	96 ab	11 cd	180 cd
DCPA 9	Bromoxynil + oxyfluorfen	0.2 + 0.17	0.2 + 0.17	0.2 + 0.17	91 ab	4 fg	100 e	100 a	7 de	101 def
DCPA 9	Clopyralid + bromoxynil	0.2 + 0.2	0.2 + 0.2	—	71 cd	10 cdef	570 de	54 c	5 ef	118 def
DCPA 9	Fluroxypyr	0.3	0.3	—	—	—	—	100 a	2 f	17 gh
DCPA 9	Fluroxypyr + bromoxynil	0.3 + 0.2	0.3 + 0.2	—	89 ab	6 efg	220 e	91 b	4 ef	39 fgh
DCPA 9	Fluroxypyr + oxyfluorfen	0.3 + 0.2	0.3 + 0.2	—	—	—	—	96 ab	6 e	67 efg
Ethofumesate 0.6	Ethofumesate + bromoxynil	0.3 + 0.2	0.3 + 0.2	—	—	—	—	41 cd	7 de	101 def
Ethofumesate 1.1	Ethofumesate + bromoxynil	0.3 + 0.2	0.3 + 0.2	—	49 ef	13 bcd	1,310 bc	31 d	6 e	107 def
Ethofumesate 2.2	Ethofumesate + bromoxynil	0.6 + 0.2	0.6 + 0.2	—	63 de	6 efg	460 de	48 c	5 ef	73 defg
DCPA 9	Cultivated three times				0	28 a	2,420 a	3 e	22 b	1,032 b
DCPA 9	Hand weeded				100	0.4 g	0	100	1 f	6 h
DCPA 9	No cultivation				—	—	—	0	41 a	2,809 a

[a] Plots were cultivated 7 to 10 d after each postemergence herbicide application.

[b] Means within a column followed by the same letter are not significantly different based on Fisher's protected LSD test at the $\alpha = 0.05$ level. Means without any variance (controls) were not included in the analysis of variance.

[c] Data analysis and mean separation are based on arcsine-transformed data. Evaluations were made on June 25, 1996 and June 26, 2000.

[d] Data analysis and mean separation are based on square root–transformed data.

1996 or 2000 compared with the hand-weeded checks (Tables 1 and 2). When cultivation was the only method of potato control, potatoes produced 28 tubers/m² (weighing 2,420 g) and 22 tubers/m² (weighing 1,032 g) in 1996 and 2000, respectively (Table 1).

In 1996 two sequential POST treatments of bentazon, pyridate, pelargonic acid, or carfentrazone at the two- and three-leaf stages of onions either failed to control potatoes or severely injured onions and were therefore not repeated in 2000 (data not shown).

Oxyfluorfen applied POST caused leaf necrosis and stunted potato growth for several weeks after each application. Potato control in late June was 94% with three applications of oxyfluorfen and cultivation in both years (Table 1). Two applications of oxyfluorfen did not control potatoes as well as three applications did in 1996, but in 2000 two applications of oxyfluorfen were as effective as three. In 1996 three applications of oxyfluorfen reduced the number of potato tubers 68% and tuber weight by greater than 90% compared with cultivation alone (Table 1). In 2000 two or three applications of oxyfluorfen followed by cultivation reduced the number of potato tubers by approximately 62% and tuber weight by 88% compared with noncultivated checks (Table 1). Although visual control of potatoes was greater with oxyfluorfen than with bromoxynil, oxyfluorfen was less effective in reducing potato tuber number and weight in 2000 (Table 1). Although not measured, there appeared to be less late-season defoliation of potatoes by Colorado potato beetle in oxyfluorfen-treated plots compared with bromoxynil-treated plots, and this may partially explain the greater tuber numbers in oxyfluorfen-treated plots in 2000. Colorado potato beetle is attracted to potatoes that are chemically and physically stressed (Bolter et al. 1997; Landolt et al. 1999). We are currently investigating the relationship between herbicide-induced stress and beetle grazing of potato.

In 1996 and 2000 bromoxynil plus oxyfluorfen controlled potatoes similar to oxyfluorfen alone (Table 1). Bromoxynil plus oxyfluorfen applied three times plus cultivation greatly reduced the number and weight of tubers produced when compared with cultivated checks in both years. The reduction in tuber number and weight with the combination was similar to that with bromoxynil alone in 2000, although visual potato control was greater when bromoxynil was applied with oxyfluorfen (Table 1).

In 1996 ethofumesate applied PRE at 1.1 or 2.2 kg ai/ha followed by ethofumesate plus bromoxynil applied POST reduced the number of potato tubers more than 50% and tuber weight by more than 45% when compared with cultivation alone (Table 1), but severely injured onions (data not shown). Injury symptoms from ethofumesate consisted of epinastic growth and thickened, curled leaves on onions. Ethofumesate applied PRE delayed potato emergence and stunted early potato growth for 4 to 7 d (data not shown). Ethofumesate was tested PRE at 0.6 kg/ha in 2000, which was much less injurious to onions (data not shown). Ethofumesate applied PRE from 0.6 to 2.2 kg/ha followed by ethofumesate plus bromoxynil POST followed by cultivation reduced the number and weight of potato tubers more than 80 and 95%, respectively, compared with noncultivated checks in 2000 (Table 1).

Two POST applications of fluroxypyr, fluroxypyr plus bromoxynil, or fluroxypyr plus oxyfluorfen at the two- and three-leaf stages of onions caused epinastic growth of potato foliage, which lasted for several weeks after each application (data not shown). Two applications of fluroxypyr plus bromoxynil at the two- and three-leaf stages of onions controlled potatoes about 90% by late June in both years (Table 1). Fluroxypyr plus bromoxynil applied twice greatly reduced potato tuber number and weight, similar to three applications of oxyfluorfen or oxyfluorfen plus bromoxynil in 1996 (Table 1). In 2000 two applications of fluroxypyr alone reduced potato tuber weight the most, and applying fluroxypyr with bromoxynil or oxyfluorfen controlled potatoes similar to fluroxypyr applied alone (Table 1). Many potato tubers collected from fluroxypyr-treated plots rotted during storage (data not shown). Tubers collected from fluroxypyr-treated plots produced only 0.6 sprouts/tuber, whereas tubers collected from cultivated checks produced 6 sprouts/tuber (data not shown). Sprouts on fluroxypyr-treated tubers were thinner in diameter than sprouts on untreated tubers. Tubers from fluroxypyr-treated plants exhibited blackening during storage in a previous study but produced normal sprouts (Bevis and Jewel 1986).

Two or three POST applications of bromoxynil did not control potatoes as well as oxyfluorfen did in both years (Table 1). Bromoxynil at 0.3 kg/ha caused chlorotic potato foliage and some minor leaf necrosis for several weeks after each application, but the plants eventually recovered. In 1996 potato tuber weight was reduced only 35% with two applications and 64% with three applications of bromoxynil compared with cultivation alone (Table 1). In 2000 two or three applications of bromoxynil plus cultivation reduced the number of potato tubers more than 63% and the weight of potato tubers more than 86% compared with cultivated checks, although visual control in late June was only 45% (Table 1).

Table 2. Onion yield after treatment with herbicides and cultivation for volunteer potato control in 1996 and 2000.[a]

Preemergence	Herbicide	Onion stage when herbicide was applied: Two leaf	Three leaf	Four to five leaf	1996[b]: Total yield	Diam.[c] > 7.6 cm	2000: Total yield	Diam. > 7.6 cm
(kg ai/ha)		(kg ai/ha)			(kg × 10^3/ha)			
DCPA 9	Bromoxynil	0.3	0.3	—	17 bcd	1.0 cde	68.0 cdef	49.1 cdef
DCPA 9	Bromoxynil	0.3	0.3	0.3	18.0 bc	1.1 cd	71.0 bcde	52.5 bcde
DCPA 9	Oxyfluorfen	0.2	0.2	—	45.3 a	13.8 ab	73.4 abcde	55.9 abcd
DCPA 9	Oxyfluorfen	0.2	0.17	0.17	53.3 a	22.3 a	83.5 abc	69.9 ab
DCPA 9	Bromoxynil + oxyfluorfen	0.2 + 0.17	0.2 + 0.17	—	25.3 b	2.4 bc	85.6 ab	70.7 ab
DCPA 9	Bromoxynil + oxyfluorfen	0.2 + 0.17	0.2 + 0.17	0.2 + 0.17	48.0 a	21.6 ab	81.2 abcd	66.0 abc
DCPA 9	Clopyralid + bromoxynil	0.2 + 0.2	0.2 + 0.2	—	7.4 de	0 e	10.5 i	1.8 i
DCPA 9	Fluroxypyr	0.3	0.3	—	—	—	63.3 efg	41.4 defg
DCPA 9	Fluroxypyr + bromoxynil	0.3 + 0.2	0.3 + 0.2	—	17.4 bcd	0.7 cde	55.0 fgh	34.5 efg
DCPA 9	Fluroxypyr + oxyfluorfen	0.3 + 0.2	0.3 + 0.2	—	—	—	66.8 def	48.8 cdef
Ethofumesate 0.6	Ethofumesate + bromoxynil	0.3 + 0.2	0.3 + 0.2	—	—	—	78.7 abcde	62.6 abc
Ethofumesate 1.1	Ethofumesate + bromoxynil	0.3 + 0.2	0.3 + 0.2	—	6.6 e	0.5 de	47.2 gh	29.4 fgh
Ethofumesate 2.2	Ethofumesate + bromoxynil	0.6 + 0.2	0.6 + 0.2	—	2.4 f	0.2 cde	19.6 i	10.9 hi
DCPA 9	Cultivated three times				13.8 cde	0.5 cde	44.0 h	22.7 gh
DCPA 9	Hand weeded				52.0 a	23.4 a	88.1 a	74.0 a
DCPA 9	No cultivation				—	—	11.5 i	0.9 i

[a] Plots were cultivated 7 to 10 d after each postemergence herbicide application.
[b] Means within a column followed by the same letter are not significantly different based on Fisher's protected LSD test at the $\alpha = 0.05$ level.
[c] Data analysis and mean separation are based on log-transformed data.

Two POST applications of clopyralid plus bromoxynil caused epinastic growth of potato foliage, which lasted most of the season (data not shown). Clopyralid injury symptoms on potato foliage were similar to those described previously (Boydston 1994). Two applications of clopyralid plus bromoxynil followed by cultivation controlled potatoes 71 and 54% by late June in 1996 and 2000, respectively (Table 1). Two applications of clopyralid plus bromoxynil followed by cultivation reduced the number of potato tubers similar to two applications of bromoxynil alone in both years (Table 1).

Onion Yield. Onion yield in hand-weeded checks averaged 52,000 and 88,100 kg/ha in 1996 and 2000, respectively (Table 2). Temperature data collected by an automated weather station located within 0.25 km of the research site indicated that 186 more heat units were accumulated in May and June of 2000 than for the same period in 1996. The relatively warmer conditions in 2000 favored onion growth relative to potato growth and were reflected in higher onion yields in 2000. Changes in onion variety each year may have also contributed to differences in yield. In 2000, potatoes in noncultivated checks reduced onion yield 87% compared with the hand-weeded checks (Table 2). When cultivation was the only method of potato control, onion yield was reduced 73 and 50% compared with the hand-weeded checks in 1996 and 2000, respectively (Table 2).

Onions treated with two or three POST applications of oxyfluorfen plus cultivation yielded similar to hand-weeded checks in both years (Table 2). Likewise, the yield of large onions with a diameter > 7.6 cm was greatest in treatments containing three applications of oxyfluorfen (Table 2).

In both years the total onion yield and the yield of onions > 7.6 cm in diameter were similar when comparing three POST applications of bromoxynil plus oxyfluorfen and the hand-weeded checks. Onion yield was lower in 1996 with two applications of bromoxynil plus oxyfluorfen than with two applications of oxyfluorfen alone (Table 2). The slightly lower rate of oxyfluorfen used in the combination with bromoxynil compared with oxyfluorfen alone may account for the slightly lower potato control (although not statistically significant) and lower onion yield observed with the combination in 1996.

Ethofumesate applied PRE at 1.1 or 2.2 kg/ha followed by ethofumesate plus bromoxynil applied POST greatly reduced onion yield compared with the hand-weeded checks in both years (Table 2). In 2000 ethofumesate at 0.6 kg/ha applied PRE followed by two POST applications of ethofumesate plus bromoxynil did not reduce onion yield or yield of onions with diameter greater than 7.6 cm compared with the hand-weeded checks (Table 2) and may be a promising treatment for potato control in onions. Ethofumesate injury to onions could possibly be reduced with different irrigation methods and soil types.

In 1996 two applications of fluroxypyr plus bromoxynil injured onions (injury data not shown) and reduced onion yield 66% and yield of large-diameter onions 97% compared with the hand-weeded checks (Table 2). In 2000 fluroxypyr applied twice reduced onion yield 28%, and applying fluroxypyr with bromoxynil tended to increase onion injury and decrease onion yield (Table 2). Fluroxypyr injury to onions consisted of curled and twisted leaves and more prostrate growth for 7 to 10 d after each application. Fluroxypyr injury to onion was excessive at the rates used in this study, but fluroxypyr may be useful for volunteer potato suppression in onions if applied at lower rates than those tested in this study. Two applications of fluroxypyr at 0.14 kg/ha have suppressed volunteer potatoes in sweet corn (*Zea mays* L.) (personal observations). However, two applications of fluroxypyr at 0.1 kg/ha or three applications at 0.05 kg/ha in leeks (*Allium porrum* L.) did not control volunteer potatoes well (Runham et al. 1993a).

Two or three POST applications of bromoxynil slightly injured onions (data not shown) and onion yield was reduced by about 66 and 20% in 1996 and 2000, respectively, compared to hand-weeded checks (Table 2). Reduction in onion yield was likely the result of interspecific competition from uncontrolled potatoes rather than herbicide injury, given that visual injury to onions was transient and onions treated with bromoxynil plus oxyfluorfen yielded equal to hand-weeded checks.

Two POST applications of clopyralid plus bromoxynil injured onions and reduced onion yield 86 to 88% compared with the hand-weeded checks and nearly eliminated the yield of onions larger than 7.6-cm diameter in both years (Tables 2) and would, therefore, not be suitable for use in onions as tested in this study. Clopyralid injured onions when following treatments of fluroxypyr or when applied with fluroxypyr in previous studies (Bond 1993; Runham et al. 1993b).

Potatoes that survived control treatments were severely defoliated in late July and August by Colorado potato beetles in both 1996 and 2000, but defoliation apparently occurred too late to prevent onion yield loss from early-season potato competition. None of the herbicide plus cultivation treatments tested completely eliminated potatoes, but treatments containing ethofumesate, oxyfluorfen, and fluroxypyr provided the most complete control. This early-season control followed by later-season defoliation by Colorado potato beetle was adequate to eliminate yield loss in onions associated with potato competition. The contribution of Colorado potato beetle grazing to volunteer potato control and the possible differential attraction of beetles to herbicide-stressed plants warrants further investigation.

Managing volunteer potatoes in rotation crops can be broken down into three main goals: (1) reducing volunteer potato competition with the main crop to prevent yield loss; (2) reducing new tuber formation to reduce the control measures required in the succeeding crop; and (3) restricting the number of volunteer potatoes serving as hosts for potato diseases and pests. Nearly all the treatments that combined a herbicide application and cultivation achieved the goal of reducing the number of new tubers produced and would presumably reduce the number of potato plants available to serve as hosts for diseases and pests in subsequent years.

Multiple applications of oxyfluorfen combined with cultivation achieved the goal of maintaining onion yield in both 1996 and 2000. Sequential applications of oxyfluorfen at the rates used in this study are currently labeled in onions. The minimum allowed spray volume listed on the oxyfluorfen label for onions is 374 L/ha. The relatively good control of potatoes obtained in this study with oxyfluorfen may have resulted, in part, from the complete spray coverage achieved with higher spray volumes of 470 L/ha. Complete spray coverage is essential for oxyfluorfen activity on larger weeds, and greater spray volumes improve control (West et al. 1986; Zandstra and Wallace 1989).

Onion injury is generally less when POST herbicides are applied after onions have at least two leaves. However, volunteer potatoes emerge early in the growing season and can be quite large by the time onions reach the two-leaf stage. The delay in potato emergence observed with ethofumesate applied PRE might be a useful tool for volunteer potato management by allowing for a more effective treatment of smaller potato plants with POST herbicide applications when onions have reached the two-leaf stage of growth.

Controlling volunteer potatoes requires an integrated approach that includes timely application of herbicides, cultivation, hand weeding, crop competition, and use of biological controls. Combining these tactics can significantly reduce the impact of the weed on the rotation crop and reduce the weight and number of potato tubers formed, thereby reducing the potential of volunteer potato in successive crops.

ACKNOWLEDGMENT

We thank Treva Anderson for her excellent technical support.

LITERATURE CITED

Bevis, A. J. and S. N. Jewell. 1986. Preliminary results from the use of chemicals or cultivations to control potato groundkeepers. Asp. Appl. Biol. 13:201–208.

Bolter, C. J., M. Dicke, J.J.A. Van Loop, J. H. Visser, and M. A. Posthumus. 1997. Attraction of Colorado potato beetle to herbivore-damaged plants during herbivory and after its termination. J. Chem. Ecol. 23:1003–1023.

Bond, W. 1993. Evaluation of ioxynil, fluroxypyr and clopyralid for the control of volunteer potato in vegetable crops. Asp. Appl. Biol. 35:123–130.

Boydston, R. A. 1994. Clopyralid persistence in spearmint (*Mentha cardiaca*) hay injures potato (*Solanum tuberosum*). Weed Technol. 8:296–298.

Boydston, R. A. 2001. Volunteer potato (*Solanum tuberosum*) control with herbicides and cultivation in corn (*Zea mays*). Weed Technol. 15:461–466.

Cleal, R. 1994. Volunteer potatoes; testing strategies for a perennial problem. Br. Sugar Beet Rev. 62:20–24.

Cleal, R.A.E., C. F. Hayward, and P. J. Rawlings. 1993. Integrated control of volunteer potatoes in cereals and sugar beet. Asp. Appl. Biol. 35:139–148.

Eberlein, C. V., M. J. Guttieri, and F. N. Fletcher. 1993. Broadleaf weed control in potatoes (*Solanum tuberosum*) with postemergence directed herbicides. Weed Technol. 7:298–303.

Landolt, P. J., J. H. Tumlinson, and D. H. Alborn. 1999. Attraction of Colorado potato beetle (Coleoptera: Chrysomelidae) to damaged and chemically induced potato plants. Environ. Entomol. 28:973–978.

Lumkes, L. M. 1974. Research on the control of volunteer potatoes in the Netherlands. Proc. Br. Weed Contr. Conf. 12:1031–1040.

Lutman, P. J. 1977. Investigations into some aspects of the biology of potatoes as weeds. Weed Res. 17:123–132.

May, J. J. and J. G. Hilton. 1993. Control of volunteer potatoes in sugar beet. Asp. Appl. Biol. 35:89–96.

Oglivy, S. E., R.A.E. Cleal, and D. S. Rogers-Lewis. 1989. The control of potato groundkeepers in cereal crops. Brighton Crop Prot. Conf., Weeds. 1:205–212.

Perombelon, M.C.M. 1975. Observations on the survival of potato groundkeepers in Scotland. Potato Res. 18:205–215.

Runham, S. R., J. S. Davies, W. Bond, and M. J. Leatherland. 1993a. Weed control strategies for volunteer potatoes in leeks (*Allium porri*). Asp. Appl. Biol. 35:105–112.

Runham, S. R., J. S. Davies, and M. J. Leatherland. 1993b. Weed control strategies for volunteer potatoes in onions. Asp. Appl. Biol. 35:113–121.

Thomas, P. E. 1983. Sources and dissemination of potato viruses in the Columbia Basin of the Northwestern United States. Plant Dis. 67:744–747.

West, L. D., B. Mitsui, and T. C. Tillett. 1986. The effect of spray volume on the postemergence activity of oxyfluorfen and glyphosate combinations. Proc. West. Soc. Weed Sci. 39:219.

Williams, M. M., II, and R. A. Boydston. Effect of shoot removal during tuberization on volunteer potato (*Solanum tuberosum*) tuber production. Weed Technol: 618–620.

Wright, G. C. and G. W. Bishop. 1981. Volunteer potatoes as a source of potato leafroll virus and potato virus X. Am. Potato J. 58:603–609.

Zandstra, B. H. and T. F. Wallace, Jr. 1989. Postemergence weed control in onions (*Allium cepa*) with air-assisted, flat fan, rotary nozzles. Weed Technol. 3:467–471.